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SECTION 8 CORRECTION
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VOIR CERTIFICATE

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(54) Purification Process for Bitumen Froth

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Certificat de correction*

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Granted: December 24, 1991

Les corrections suivantes sont faites en
raison de l'article 8 de la *Loi sur les
brevets* et le document doit être lu tel
que corrigé.

In the Patent file and Patent grant:

The following corrections are made
pursuant to section 8 of the *Patent Act*
and the document should read as
corrected.

1.

The following lines have been added to the top
of page two of the claims:

"mixing the first underflow stream from the first settler
in the second mixer with a second recycled overflow
stream from the third settler, said second overflow
stream being"

Agent certifié / Certifying Officer

November 29, 1999

Date



Industrie
Canada

Industry
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(CIPO 25)

Canada

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1 "PURIFICATION PROCESS FOR BITUMEN FROTH"

2 ABSTRACT OF THE DISCLOSURE

3 Bitumen froth is treated in a circuit comprising a
4 plurality of serially connected mixer and inclined plate
5 settler units. A light hydrocarbon diluent moves
6 countercurrently through the circuit. Thus, as the bitumen
7 content of the stream being settled diminishes, the
8 concentration of diluent in that stream increases.

FIELD OF THE INVENTION

This invention relates to a process for purifying bitumen froth, to thereby obtain a diluted bitumen stream of good enough quality to be fed to a downstream upgrading facility. By 'purifying' is meant that water and solids present in the froth are separated from the bitumen.

BACKGROUND OF THE INVENTION

The oil sands of the Fort McMurray region of Alberta are presently being exploited by two large commercial operations. The process practised in these operations involves four broad steps, namely:

- mining the oil sand;
- extracting the bitumen from the mined oil sand using a process known as the 'hot water process', to produce bitumen in the form of a froth contaminated with water and solids;
- purifying the froth to separate the water and solids from the bitumen; and
- upgrading the purified bitumen in a coking facility to produce products which are suitable for a conventional refinery.

The present invention has to do with the purifying step. However, in order to understand the problems solved by the invention, it is first necessary to review the steps of the hot water process and the conventional froth purification process.

As a beginning point, it needs to be understood that oil sands comprises relatively large quartz sand grains, each grain being encapsulated in a thin sheath of connate water. The water contains minute clay particles (referred to



1 as 'fines'). The bitumen is positioned in the interstices
2 between the water-sheathed grains of sand.

3 In the first step of the hot water process, the
4 mined oil sand is mixed in a rotating horizontal cylindrical
5 drum (or 'tumbler') with hot water (80°C) and a small amount
6 of NaOH (referred to as 'process aid'). Steam is sparged
7 into the slurry at intervals along the length of the drum, to
8 ensure that the exit temperature of the resultant slurry is
9 about 80°C.

10 The drum is slightly inclined along its length, so
11 that the mixture moves steadily therethrough. The retention
12 time is about 4 minutes.

13 This tumbling step is referred to as
14 'conditioning'. It involves heating of the bitumen and
15 displacement, by water addition, of the bitumen away from the
16 sand grains. Many of the released bitumen globules become
17 aerated by forming films around air bubbles entrained in the
18 tumbler slurry. Conditioning also involves reaction between
19 the NaOH and bitumen to produce surfactants which facilitate
20 the bitumen-release and subsequent flotation/settling steps.

21 On leaving the tumbler, the conditioned slurry is
22 screened, to remove oversize rocks and lumps, and diluted
23 with additional hot water. The resulting water/bitumen ratio
24 is about 6:1.

25 The diluted slurry is then introduced into a large
26 thickener-like vessel having a cylindrical upper portion and
27 a conical lower portion. The vessel is referred to as the
28 'primary separation vessel' or 'PSV'. Here the diluted
29 slurry is retained for about 45 minutes under quiescent
30 conditions. Under the influence of gravity, the sand grains
31 sink, are concentrated in the conical portion and are

1 discharged as 'primary tailings' through a valve and line
2 connected to the lower apex of the vessel. The bitumen
3 globules, rendered buoyant by air attachment, rise to the
4 surface of the PSV and form a froth. This froth is called
5 'primary froth' and typically comprises:

6 66.4% by wt. bitumen

7 24.7% by wt. water

8 8.9% by wt. solids

9 The primary froth is skimmed off and recovered in a launder.
10 In between the layer of sand tailings in the base of the
11 vessel and the layer of froth at the top, there exists a
12 watery slurry referred to as 'middlings'. The middlings
13 contain fines and globules of bitumen which are
14 insufficiently buoyant to reach the froth layer.

15 A stream of middlings is continuously withdrawn
16 from the PSV. These middlings are treated in a series of
17 sub-aerated flotation cells. In these cells, the middlings
18 are vigorously aerated and agitated, with the result that
19 contained bitumen is forced to float and form a dirty froth
20 referred to as 'secondary froth'. This secondary froth
21 typically comprises:

22 23.8% by wt. bitumen

23 58.7% by wt. water

24 17.5% by wt. solids.

25 To reduce the concentration of water and solids in
26 the secondary froth, it may be retained in a settling tank to
27 allow some of the contaminants to settle out. The 'cleaned'
28 secondary froth typically comprises:

29 41.4% by wt. bitumen

30 46.2% by wt. water

31 12.4% by wt. solids.

1 The primary and secondary froths are then combined
2 to provide the product of the hot water extraction process.
3 The 'combined froth' typically comprises:

4 57.3% by wt. bitumen
5 34.2% by wt. water
6 8.4% by wt. solids.

7 This stream is too contaminated to be used as feed
8 to the downstream upgrading circuit. This latter circuit
9 requires a feed typically comprising:

10 99.0% by wt. bitumen
11 - % by wt. water
12 1.0% by wt. solids.

13 So the combined froth product requires purification
14 (or water and solids removal) before it can be fed to the
15 upgrading circuit. Heretofore, this purification has been
16 obtained by using what is referred to as 'two stage dilution
17 centrifuging'. This operation involves:

- 18 1. Diluting the combined froth with naphtha.
19 This is done to reduce hydrocarbon phase
20 viscosity and increase the density
21 difference between the hydrocarbon phase
22 (bitumen dissolved in naphtha) and the
23 water and solids phase (referred to jointly
24 as 'sludge');
25 2. Passing the diluted froth through a low-
26 speed scroll centrifuge, to remove the
27 coarse solids and some of the water as a
28 cake , which is discarded; and

1 3. Passing the scroll centrifuge product
2 through a high-speed disc centrifuge to
3 remove fine solids and most of the balance
4 of the water. The disc centrifuge product
5 typically analyzes at:

6 59.4% by wt. bitumen

7 37.5% by wt. naphtha

8 4.5% by wt. water

9 0.4% by wt. solids

10 The naphtha diluent and any contained water is then
11 distilled out of the disc centrifuge product to produce the
12 purified bitumen product for advancing to the upgrading
13 process.

14 The described dilution centrifuging process has
15 been used because it is capable of producing a bitumen
16 product of the desired quality. But it is an operation that
17 is exceedingly expensive to maintain and operate due to the
18 erosive nature of the feed and the rotating character of the
19 centrifuges. For example, in use, the flights of the scroll
20 centrifuges wear badly, even though they are formed of
21 ceramic, and the brittle ceramic flights commonly break and
22 put the machine out of balance. In the case of the disc
23 centrifuges, their sludge discharge nozzles are subject to
24 rapid wear and the separation interface between product and
25 reject in the stack of discs can easily be 'lost', with the
26 result that a significant amount of bitumen is lost with the
27 tailings. In addition, a large number of the machines must
28 be used, with attendant consumption of very large amounts of
29 electrical energy.

1 Thus, there has long been a need for a viable
2 alternative to the dilution centrifuging circuit for
3 purifying bitumen froth.

4 The present invention involves a circuit of
5 interconnected known devices, namely mixers and inclined
6 plate settlers ('IPS').

7 An inclined plate settler comprises a stack of
8 parallel, spaced apart, solid plates, inclined downwardly
9 from the horizontal and mounted within a containing vessel.
10 Each space between a pair of plates forms a discrete settling
11 zone. The feed mixture to be separated is distributed into
12 the spaces, at a point between their longitudinal ends. The
13 light components of the mixture rise to the underside surface
14 of the upper plate. These light components then travel up
15 said underside surface and are collected and recovered at the
16 upper ends of the plates. The heavy components of the
17 mixture sink towards the uppermost surface of the lower plate
18 and follow it downwardly, to be collected and recovered at
19 the lower ends of the plates.

20 A mixer can take any of various forms - the present
21 work involved simply a cylindrical container having a
22 submerged driven impellor positioned therein.

23 SUMMARY OF THE INVENTION

24 The present invention is based on the following
25 experimentally determined observations:

- 26 - That bitumen froth is amenable to high quality
27 separation in a first IPS, but in that first
28 stage of separation only part of the bitumen
29 in the feed reports as overhead product;

- 1 - That the underflow from the first IPS, containing
2 a significant proportion of the bitumen in the
3 original feed, is not amenable to high quality
4 separation in a second IPS. It appears that the
5 first stage underflow contains stable emulsions
6 that will not readily resolve in the second IPS
7 or that much of the hydrocarbons that did not
8 report to the overflow in the first stage will
9 also not report to the overflow in the second
10 stage; and
11 - That if light hydrocarbon diluent (e.g. naphtha)
12 is mixed with the first stage underflow, then
13 this mixture is amenable to good quality
14 separation in the second IPS.

15 Having conceived and tried the underlying
16 experimental work that resulted in these observations,
17 applicants conceived a purification circuit for bitumen froth
18 that would incorporate the following features:

- 19 - the use of a plurality of serially connected
20 inclined plate settlers, with a subsequent
21 settler being fed the underflow from a
22 preceding settler;
23 - the addition of light hydrocarbon
24 diluent or solvent, in a progressively
25 richer concentration, to the bitumen-
26 containing stream moving through the
27 series of settlers, said bitumen-containing
28 stream becoming progressively leaner in
29 bitumen as it moves through the circuit; and

- 1 - the use of mixers before each settler to mix
2 the added diluent with the bitumen.

3 A circuit or line consisting of three pairs of alternating mixers
4 and settlers was tested. The overflow stream from the first
5 settler provided the only bitumen product stream produced from
6 the circuit. The bitumen/diluent overflow stream from the second
7 settler was recycled to the first mixer to be combined with the
8 froth feed. The low-bitumen/high-diluent overflow stream from
9 the third settler was recycled to the second mixer. Thus more
10 diluent was supplied to the relatively bitumen-lean underflow
11 stream being supplied to the second mixer. And finally, fresh
12 diluent was supplied to the third mixer to dissolve the small
13 amount of bitumen in the underflow stream of the second settler.

14 When applied to typical combined bitumen froth this
15 circuit demonstrated:

- 16 - that the bitumen product stream from the first
17 IPS was of the same order of purity as that
18 derived from a conventional dilution centrifuging
19 circuit; and
20 - that the recovery of bitumen by the test circuit
21 was of the same order as that obtained by
22 dilution centrifuging.

23 Stated otherwise, we have made the surprising discovery
24 that a process using three mixing/IPS separation steps in
25 series, combined with a counter flow of solvent, gives product
26 of as good quality as that obtained from the centrifuge process
27 (said quality being referred to as "upgrading quality"),
28 together with comparable hydrocarbon recovery and a sludge
29 tailings that is substantially hydrocarbon-free. And the

1 components of the present circuit are without moving parts
2 (except for the pumps and impellers) and thus are
3 characterized by comparatively low maintenance costs.

4 DESCRIPTION OF THE DRAWINGS

5 Figure 1 is a block diagram showing the steps of
6 the process in accordance with the preferred embodiment; and

7 Figure 2 is a schematic showing the circuit of
8 processing components or units and their pipe
9 interconnections.

10 DESCRIPTION OF THE PREFERRED EMBODIMENT

11 The test work underlying the present invention was
12 carried out in 3-stage mixer/IPS circuit. The invention will
13 now be described with respect to that circuit, although it
14 could also be conducted in 2, 4 or even more stages.

15 More particularly, combined bitumen froth was fed
16 to a circuit A comprising: a first mixer 1; a first IPS 2; a
17 second mixer 3; a second IPS 4; a third mixer 5; a third IPS
18 6; and appropriate connecting lines.

19 The combined froth was introduced into and mixed in
20 the first mixer 1 with a first recycled overhead stream from
21 the second IPS 4. This first recycled overhead stream was
22 depleted in bitumen but enriched in naphtha, relative to the
23 combined froth feed.

24 The first mixer 1 comprised a cylindrical body 1a
25 having a flat bottom 1b. An impellor 1c was positioned to
26 stir the contents of the mixer.

The mixture from the first mixer 1 was fed to the inlet of the first IPS 2. The first IPS 2 was simply a box 2a having an inlet 2b, an overhead outlet 2c, and an underflow outlet 2d. The box contained a pair of inclined spaced-apart plates 2e.

The dimensions of the mixer and IPS units used are set forth in Table 1. The several mixers and IPS's in the circuit were identical to the described units.

TABLE I

Length of IPS -	5'
Spacing between plates -	1-1/2"
Dimensions of plates -	5' x 1'
Mixer vessel -	12" diameter
	12" to 16" of liquid
	in the vessel during
	operation
Type of impellor -	6" diameter marine
	propeller
Impellor rpm -	220 - 680

Separation of the bitumen, water, and solids, present in the mixture fed from the first mixer 1, took place in the first IPS 2. A first overhead product stream, which was the only bitumen-rich product from the circuit, was obtained. This stream was enriched in bitumen relative to the original froth feed. (The compositions of these streams are set forth in Table II below.)

The underflow stream from the first IPS 2 was fed to the second mixer 3. Here it was mixed with a second recycled stream from the third IPS 6. This second recycled stream was very depleted in bitumen but relatively rich in naphtha.

1 The mixture from the second mixer 3 was fed to the
2 inlet of the second IPS 4. Separation occurred therein and
3 overflow and underflow streams were produced. The overflow
4 stream was the stream recycled to the first mixer, as
5 previously stated.

6 The second underflow stream, produced by the second
7 IPS 4, was fed to the third mixer 6. This second underflow
8 stream was quite lean in bitumen - more particularly, it was
9 depleted in bitumen relative to the first underflow stream.

10 In the third mixer 6, the second underflow stream
11 was mixed with fresh pure naphtha. The mixture was fed to the
12 inlet of the third IPS 6 and underwent separation therein.
13 The overflow stream from the third IPS 6 was recycled to the
14 second mixer 3, as previously stated. The underflow stream,
15 virtually free of bitumen, was discarded as tails.

16 The stream compositions and separation results are
17 set forth in Table II.

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TABLE II

COMPOSITION (% BY WT.)

STREAM	BITUMEN	WATER	SOLIDS	NAPHTHA	RATE kg/min
Combined froth feed	57.3	34.2	8.5	-	1.96
First recycled overflow (from 2nd. IPS)	19.7	14.1	1.9	63.4	1.59
Overflow product (from 1st IPS)	55.7	4.7	0.7	39.0	2.02
1st IPS underflow	20.7	52.7	12.1	14.5	1.52
Second recycled overflow (from 3rd IPS)	2.80	53.8	8.3	35.1	3.01
2nd IPS underflow	2.9	13.7	74.6	9.3	2.95
Fresh diluent				99.5	0.81
3rd IPS underflow	0.20	77.3	20.3	2.4	0.75

1 SUPPLEMENTARY DISCLOSURE

2 This supplementary disclosure relates to a
3 variation of the circuit described in the principal
4 disclosure.

5 It can be advantageous to operate the separation
6 process at elevated temperature because the viscosity of the
7 hydrocarbon is thereby reduced. This allows the solid
8 particles to settle more rapidly. In addition, at higher
9 temperature the water droplets coalesce more readily, which
10 facilitates their separation from the hydrocarbon. A high
11 purity product is thereby produced at lower residence time,
12 with the consequence that the capacity of the equipment is,
13 in effect, increased.

14 At such higher temperatures, fractions of the
15 diluent can approach or exceed their atmospheric boiling
16 point. To prevent flashing of the diluent, and to contain
17 the pressures generated, it is necessary to surround the
18 functioning units of the equipment with pressure-retaining
19 housings.

20 This may be effected in conventional fashion by
21 closing in the components of the circuit, as indicated
22 diagrammatically in Figure 3, and operating the process at
23 elevated temperature and pressure.

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1 THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
2 PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

3 1. A process for purifying bitumen froth from the hot
4 water process for extracting bitumen from oil sand, said froth
5 comprising bitumen, water and solids, said process being carried
6 out in a circuit comprising first, second and third inclined
7 plate settlers and first, second and third mixers, each settler
8 having an inlet, an overflow outlet and an underflow outlet, each
9 mixer having an inlet and outlet, each mixer being positioned
10 before the corresponding settler, the outlet of each mixer being
11 connected with the inlet of the immediately downstream settler,
12 the inlet of the first mixer being connected with a source of
13 bitumen froth, the inlet of the second mixer being connected with
14 the underflow outlet of the first settler, the inlet of the third
15 mixer being connected with the underflow outlet of the second
16 settler, the overflow outlet of the first settler providing the
17 diluted bitumen product from the circuit, the overflow outlet of
18 the second settler being connected with the first mixer, the
19 overflow outlet of the third settler being connected with the
20 second mixer, the third mixer being connected with a source of
21 light hydrocarbon diluent, said process comprising:
22 mixing the bitumen froth in the first mixer with a
23 first recycled overflow stream from the second settler, said
24 overflow stream being depleted in bitumen and enriched in diluent
25 relative to the froth;
26 treating the mixture produced from the first mixer in
27 the first settler to produce a first product overflow stream
28 which is sufficiently enriched in bitumen relative to the froth
29 to be of upgrading quality and a first underflow stream which is
30 depleted in bitumen relative to the froth;

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SECTION 8 CORRECTION
SEE CERTIFICATE
CORRECTION - ARTICLE 8
VCM CERTIFICATE

1 depleted in bitumen and enriched in diluent relative to the first
2 overflow stream;

3 treating the mixture produced from the second mixer in
4 the second settler to produce the first recycled overflow stream
5 and a second underflow stream which is depleted in bitumen
6 relative to the first underflow stream;

7 mixing the second underflow stream from the second
8 settler in the third mixer with a stream of light hydrocarbon
9 diluent from said source of light hydrocarbon diluent;

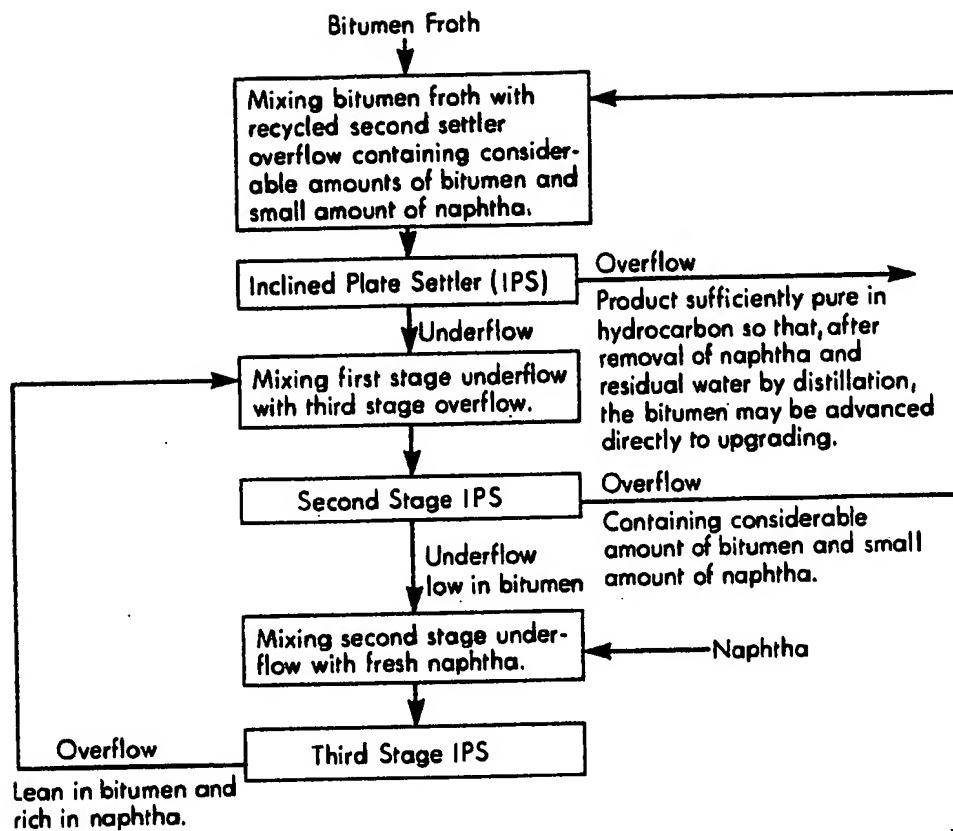
10 treating the mixture produced from the third mixer in
11 the third settler to produce the second recycled overflow stream
12 and a third underflow stream which is depleted in bitumen
13 relative to the second underflow stream.

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1 CLAIM SUPPORTED BY THE SUPPLEMENTARY DISCLOSURE

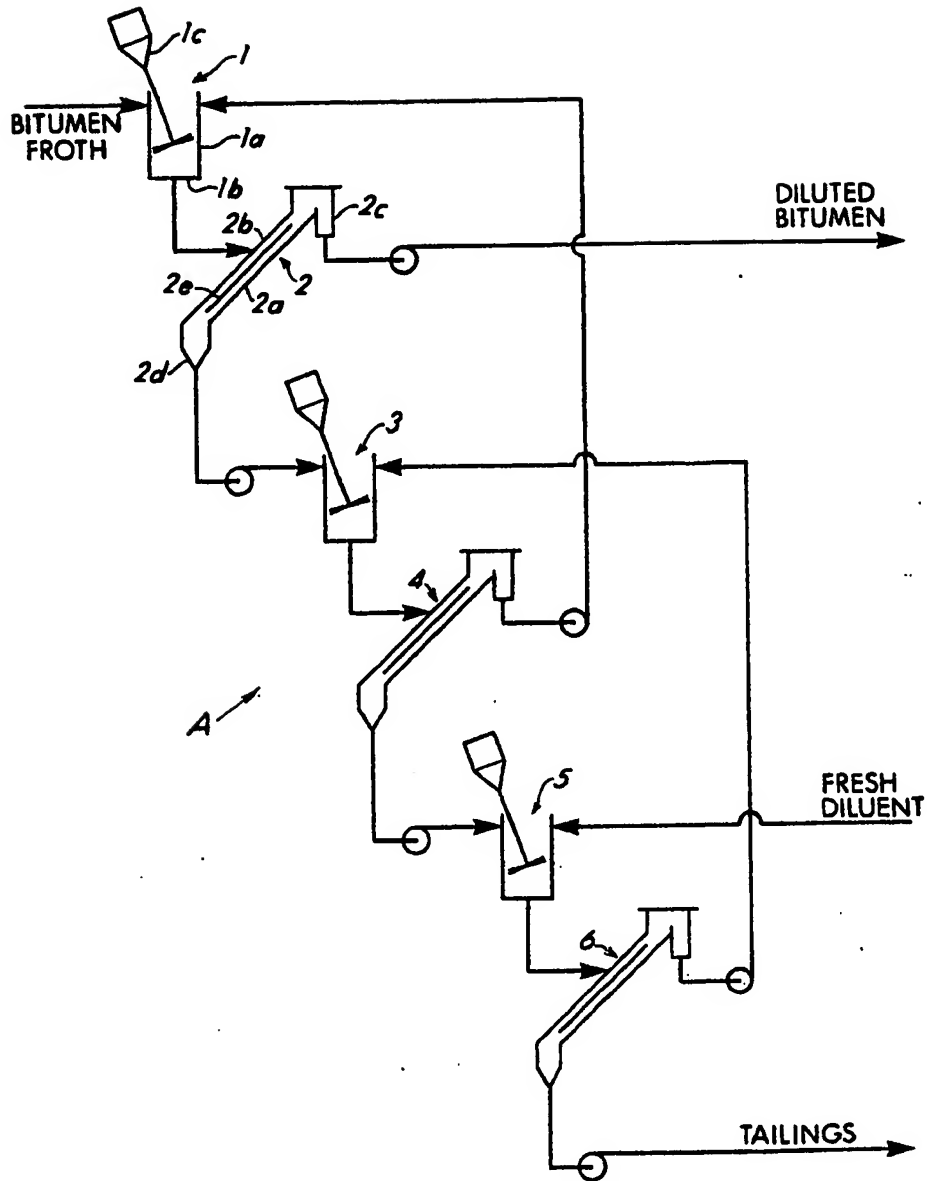
2 2. The process as set forth in claim 1 wherein:
3 the process is conducted at elevated temperature and
4 pressure and the circuit is pressure-retaining.



Fig. 1.

Patent agent:

E. P. Johnson

Fig. 2.

Patent agent:

E. P. Johnson

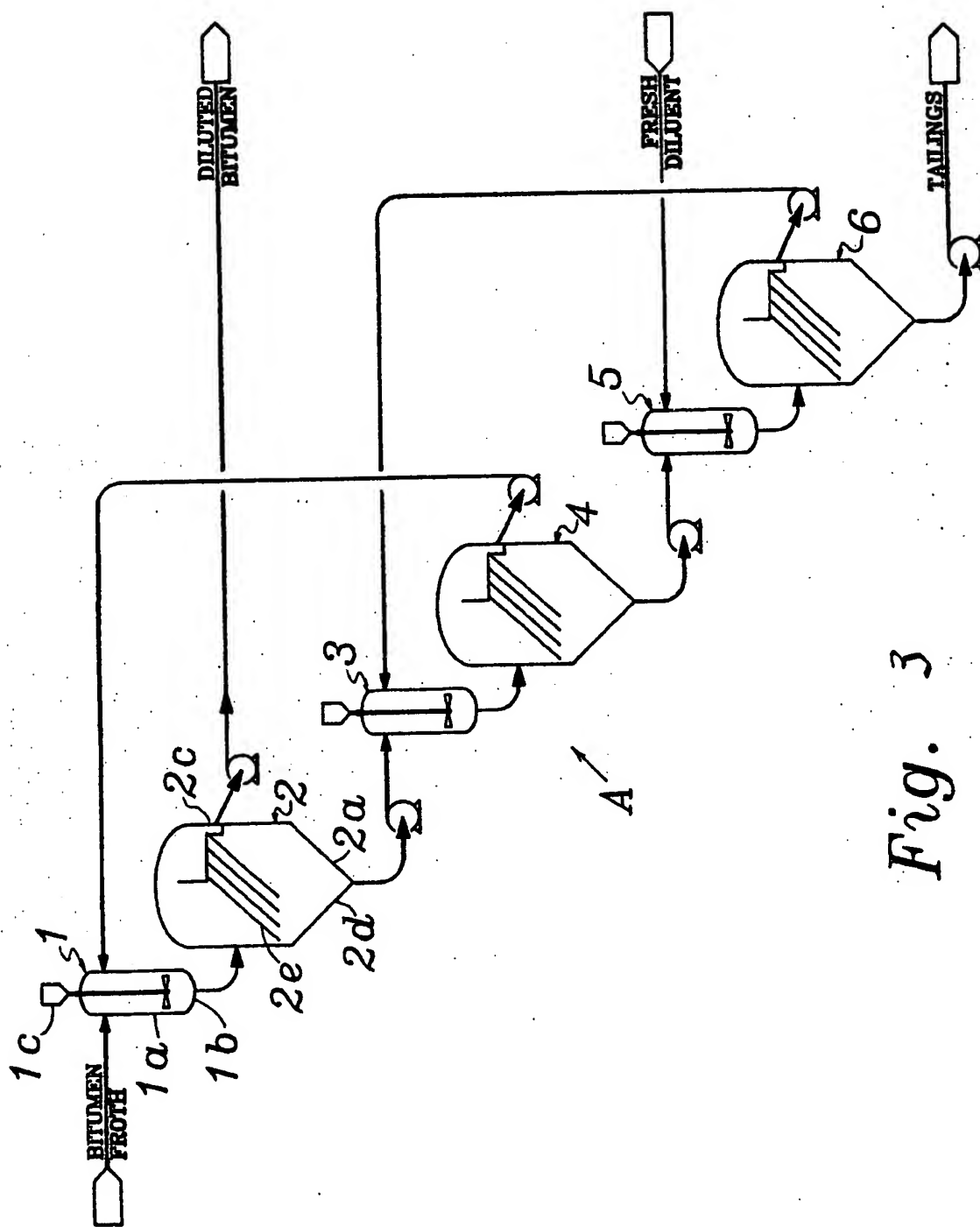


Fig. 3